

1 **COVER PAGE**

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3 **Food Security, Decision Making and the use of Remote Sensing in**  
4 **Famine Early Warning Systems**

5

6 **Abstract**

7 Famine early warning systems use remote sensing in combination with socio-  
8 economic and household food economy analysis to provide timely and rigorous  
9 information on emerging food security crises. The Famine Early Warning Systems  
10 Network (FEWS NET) is the US Agency for International Development's decision  
11 support system in 20 African countries, as well as in Guatemala, Haiti and  
12 Afghanistan. FEWS NET provides early and actionable policy guidance for the US  
13 Government and its humanitarian aid partners. As we move into an era of climate  
14 change where weather hazards will become more frequent and severe,  
15 understanding how to provide quantitative and actionable scientific information for  
16 policy makers using biophysical data is critical for an appropriate and effective  
17 response.

18

# 1. Introduction

Remote sensing is the use of environmental sensors placed in orbit to observe the earth. The sensors provide a daily global assessment of ecosystem health and the impact of weather on the land. These observations have formed the foundation of early warning systems by providing quantitative assessments of variations in food production across large areas. Famine early warning systems use satellite remote sensing information in combination socio-economic and household food economy analysis to provide timely and rigorous vulnerability information identifying emerging food security problems. Food security is the ability of all people to access enough food to live an active and healthy life.

This article focuses on how remote sensing-derived information can be used in an early warning system to provide early, actionable and relevant information to decision makers charged with responding to food security emergencies. It will describe both the broad outlines of remote sensing data used to identify weather related declines in production as well as the way food security analysis is conducted so that an understanding of the impact of these declines on overall food security of a region can be determined. Early warning organizations seek to use scientific information and interdisciplinary analysis to directly inform policy and budget decisions that lead to an appropriate response to crises (Buchanan-Smith and Davies, 1995). As we move into an era with a rapidly transforming climate that will touch upon our lives in a myriad of ways, understanding how such organizations work in the face of complex weather and climate related disasters is an important

1 first step to building systems that will respond to needs as they arise.

## 2 1.1 The Famine Early Warning Systems Network

3 The US Agency for International Development (USAID) designed the Famine Early  
4 Warning System (FEWS) in 1986 to provide information on the food security status  
5 of communities in semi-arid regions of the West African Sahel. Research conducted  
6 during and after famines in Africa in the 1970s and 1980s (von Braun et al., 1998)  
7 demonstrated that early and effective intervention could break the link between  
8 climate extremes and famine (Wisner et al., 2004). The development of remote  
9 sensing systems to monitor environmental conditions provided for the first time a  
10 way to monitor current climate variations over an entire continent for very little  
11 expense (Tucker, 1979). Before the advent of remote sensing systems, information  
12 on growing conditions was difficult to get and extremely localized, with large areas  
13 away from cities and roads left unmonitored. By combining a new understanding of  
14 the cascade of events that lead to famine (Watts, 1983) with remote sensing  
15 information for identifying and investigating widespread weather-related food  
16 production deficits, the foundation for effective early warning systems was in place.

17 Estimating the impact of climatic hazards is more challenging than simply  
18 analyzing the necessary physical evidence of an ongoing drought or the severity of a  
19 flood. There is large variation in the amount of climatic stress that vulnerable  
20 groups can endure before real and widespread destruction of livelihoods occur  
21 (Dilley, 2000). Although the physical characteristics of crop yield reductions due to  
22 rainfall deficits can be specified, determining the impact of this reduction in the  
23 place and time that it occurs is dependent on the context. For example, a 50%

reduction in millet production in Mali due to erratic rainfall that occurs after several years of good harvests is far less likely to result in sufficient food insecurity to warrant intervention than the same reduction after several years of below-average production. Just as important as the timing element is its spatial extent. Drought occurring in cropping areas has a different impact than those in pastoral lands, and the size of the area affected also can have a significant impact on food security. These complexities make interpreting climate data and linking it effectively to humanitarian intervention very challenging (Moseley, 2001). Thus FEWS NET has cultivated a broad cadre of experienced personnel, both social and physical scientists, internationally experienced experts as well as locally based personnel with experience in health, agriculture and nutrition to help it determine the food security situation in each country it works in (Table 1).

## **1.2 FEWS NET's Structure**

The most visible parts of FEWS NET are its field offices and field representatives in roughly 31 countries, and a contractor in Washington D.C. office located near USAID that manages and technically directs them. The contractor is responsible for integrating FEWS NET's global early warning information, resources and training activities, in the field and in Washington D.C., and delivering finished products to information-gathering and decision-making processes of USAID (in Washington and the field), as well as to a broad range of international partners. At the time of this writing, these offices are in the following locations (Figure 1):

- 1 • Africa: Regional offices in Niger, Kenya, and South Africa. National offices in  
2 Senegal, Mauritania, Mali, Burkina Faso, Niger, Chad, Northern Sudan (located in  
3 Khartoum), Southern Sudan (located in Nairobi), Eritrea, Ethiopia, Somalia  
4 (located in Nairobi), Kenya, Uganda, Angola, Tanzania, Rwanda, Malawi,  
5 Mozambique, Zambia, Zimbabwe, and South Africa (for coverage of Lesotho,  
6 Swaziland and Botswana).
- 7 • Central America: Guatemala
- 8 • Caribbean: Haiti
- 9 • Central Asia: Afghanistan

10

11 FEWS NET is composed primarily of local experts who work with specialists  
12 in the United States who coordinate their reporting. The field offices produce most  
13 of the reports, but the US contractor manages and coordinates all reports so that a  
14 similar message is conveyed to decision makers (Figure 2). The organization  
15 estimates local food availability, access, and utilization with a wide variety of  
16 datasets, including remote sensing data, ground measurements of food production  
17 measuring “supply”, and a wide range of other indicators meant to measure  
18 “demand” (the ability of a population to purchase food) in concert with political and  
19 economic pressures that may affect a region’s food security (Brown, 2008b).

20 Although FEWS NET’s early and actionable information can motivate intervention to  
21 break the link between climate extremes and famine (Davies et al., 1991, Wisner et  
22 al., 2004), it does not respond itself.

FEWS NET works to create coalitions through finding groups at the local, regional and international level with common interests, and form alliances to strengthen their combined ability to push for the desired outcomes. The coalition should include countries' international aid agencies (bilateral aid) such as US Agency for International Development, UK Department for International Development, EuropeAid, and the European Commission's Directorate General for Humanitarian Aid (ECHO), multilateral institutions such as the World Bank and African Development Bank, and development charities such as Oxfam, Save the Children and Care. All of these players have influence in the decision process to provide humanitarian assistance, however none have the resources to go it alone. They must find a way to work together through collaboration and coalitions to obtain their goals. FEWS NET provides data and analysis which form the basis for understanding the nature and severity of the problem, and thus increase the likelihood that an appropriate and timely response arrives in the region at risk when it is needed. Remote sensing plays a key role, as it is often the earliest indicator that there may be a problem, and is usually the least controversial, providing a focus point for negotiations and discussions among the many parties who must come to an agreement before a response can occur.

### 1.3 FEWS NET's Conceptual Frameworks

Famine early warning systems are implemented by organizations that use social and political information about the ways people gain access to food, combined with spatially extensive biophysical information to determine the onset of severe food insecurity. In order to create policy-relevant information, FEWS NET must

1 know how events will affect food security. Perturbations in the climate or rainfall  
2 are only one of many factors that are important. Figure 3 shows a summary of  
3 studies in household food security in southern Africa, where climate/environment  
4 was just one of 33 drivers of food insecurity mentioned as important by  
5 householders (Cooper et al., 2004, Gregory et al., 2005). The impact of sudden  
6 drought, for example, is felt on top of ongoing long-term stresses and the inability to  
7 cope with such shocks and to mitigate long-term stresses means that the coping  
8 strategies, such as short-term employment, may not be available, and thus the  
9 impact for one household may be far greater than another. FEWS NET needs to  
10 know and understand about the entire complex picture as well as all the potential  
11 shocks to the system in order to provide accurate and useful information about how  
12 to intervene.

13  
14       Regardless of its cause, famine is a slow-fuse disaster, a social catastrophe  
15 that takes many months or years to develop, the consequence of multiple failures on  
16 many levels before famine takes hold (von Braun et al., 1998). Early warning of this  
17 process should, therefore, be straightforward, but because there is little agreement  
18 on exactly how to measure changing food systems, and because famines can occur  
19 not only when there is no food but when food is plentiful, it is not.

20       If it takes such a long time to occur, then why are early warning systems  
21 needed? Early warning of such a slow, multi-year process involves two aspects: first  
22 an adequate capability to detect and document a crisis, and advance preparation by  
23 international, national and local organizations for an effective response to an

1 identified crisis. The role of early warning systems is to identify and allow  
2 governments the time and information needed to deter these crises from occurring,  
3 preventing the destruction of the lives and livelihoods of countless people as well as  
4 the social and economic systems on which they depend. Thus, effective early  
5 warning revolves around prior agreement as to what constitutes a crisis, and what  
6 responses will occur when such crises occur. These responses tend to be very  
7 expensive, both economically and politically, and they will not occur if there is not  
8 consensus on what needs to happen. Alternatively, if no response occurs, that can  
9 also be extremely expensive in the long run. Agreement on what is a proper  
10 response and how quickly a response should occur is difficult to achieve, especially  
11 given the diversity of local, national, and international actors involved. Famine early  
12 warning systems provide the forum both for agreement on the signs of an  
13 impending crisis, and the platform for mobilizing the preparation for response on  
14 multiple levels (Buchanan-Smith, 2000).

15       When the U.S. government responds to disaster internationally, the primary  
16 institution for managing humanitarian assistance is the U.S. Agency for International  
17 Development (USAID). Provision of this assistance is a core activity of USAID and is  
18 recognized as a strategic goal (USAID, 2007). For prevention and mitigation of  
19 disasters, USAID specifically cites the Famine Early Warning System Network  
20 (FEWS NET) as the prime example of how it is achieving this strategic priority.  
21 USAID clearly values the role this early warning system plays in reducing risk of  
22 famine, hunger and food insecurity, and, ultimately, in reducing the human and  
23 financial toll of famine.



FEWS NET is only a small part of the overall larger geo-political system that has grown up around food aid, humanitarian programs and overseas development aid. Many who are familiar with USAID's programs believe that food aid is used too often and in too many places where it cannot ameliorate the long-term problems (Murphy and McAfee, 2005). FEWS NET works to ensure that decisions regarding food aid are made with the most accurate information possible about the impact of both action and inaction is available to the decision maker. That said, there is much that can be improved in the larger food aid system and with development assistance in general. Improved information for decision making through direct intervention in the negotiation process that surrounds each disaster is the focus of FEWS NET (Choularton, 2007).

### 1.3 FEWS NET and Remote Sensing

FEWS NET's personnel are predominantly social scientists, trained in the humanitarian response field, nutrition, anthropology, economics and other social sciences. They are deeply committed to improving the response to international food security crises. They are not, however, experts in remote sensing. Using satellite-derived remote sensing information to inform social science discourses requires an intense interaction between the physical scientists who develop and present the data and the social scientists who use it in their work.

To assist in the integration of geographic information and remote sensing information into standard products and monitoring, FEWS NET has funded four regional representatives through USGS who have expertise in geographic

1 information systems and remote sensing and who can provide assistance in making  
2 accurate and effective maps, download and manipulate data and to provide training  
3 on new products for FEWS NET technical personnel. There are four USGS Regional  
4 Scientists placed in FEWS NET regional offices in the Sahel, Greater Horn of Africa,  
5 Southern Africa, and Central America. They provide technical assistance in the use  
6 of operational remote sensing products for food security analysis. These Regional  
7 Scientists play a very important role in the development of new tools and in  
8 understanding the problems and challenges of the FEWS NET representatives in the  
9 field in using remote sensing data.

10 FEWS NET has several key technical US Government partners that assist with  
11 providing, using and understanding biophysical data needed to evaluate growing  
12 conditions throughout the year. Partners in FEWS NET with USAID include the US  
13 Geological Survey (USGS), the National Aeronautics and Space Administration  
14 (NASA), and the National Oceanic and Atmospheric Administration (NOAA). NASA  
15 and NOAA collect and process satellite data that are used to monitor the vegetation  
16 condition (Normalized Difference Vegetation Index, or NDVI) and rainfall (Rain Fall  
17 Estimate, or RFE) across the entire African continent. The NDVI and RFE data are  
18 but two of the wide variety of tools used by FEWS NET to monitor agricultural  
19 conditions in Africa.

20 The four inter-agency agreements with the US Government agencies support  
21 FEWS NET's work:

- 22 • The Climate Prediction Center (CPC) at NOAA provides technical support in  
23 meteorology and climatology using satellite rainfall estimation products for

- 1 Africa, Central America and the Caribbean, and Central Asia.
- 2 • The International Programs office at the USGS EROS provides assistance in
  - 3 developing operational early warning applications and products that use
  - 4 satellite and remote sensing data. USGS also maintains the FEWS NET archive
  - 5 of tabular, vector, and raster datasets and make them available via the web.
  - 6 • The GIMMS group at NASA Goddard Space Flight Center provides satellite-
  - 7 derived vegetation data products, particularly the Normalized Difference
  - 8 Vegetation Index imagery (NDVI), for early warning activities, as well as
  - 9 conducting research on ways to improve remote sensing estimates.
  - 10 • The USDA provides FEWS NET with technically-qualified management per-
  - 11 sonnel, as well as access to USDA expertise on agriculture, markets, early
  - 12 warning, and crop estimation. USDA conducts tours that estimate the
  - 13 accuracy of crop models and agriculture production statistics that FEWS NET
  - 14 often participates in.

## 15 **2 Remote Sensing to Identify Food Production Deficits**

16 FEWS NET has used remote sensing derived indices and information to

17 estimate interannual variations in food production since its founding in 1986.

18 Although the remote sensing data that FEWS NET uses are still too coarse to

19 determine how a particular individual or community's fields are doing, it provides

20 an overview of how the growing season is progressing over a region. FEWS NET

21 currently uses a merged satellite-gauge product for its primary source of

22 information on rainfall in the countries where it works. The product currently being

1 used by FEWS NET is the Rainfall Estimate (RFE) 2.0, which uses several techniques  
2 to estimate precipitation while also using traditional cloud top temperature and  
3 station rainfall data. The RFE data is particularly useful for FEWS NET because it  
4 uses the WMO Global Telecommunication System (GTS) rainfall observation data  
5 taken from ~1000 stations which are assumed to be the true daily rainfall near each  
6 station for each day. Using these observations in the rainfall model produces a  
7 dataset which is far closer to the observed rainfall in all locations where  
8 observations are taken.

9  
10 Vegetation estimates, although available at a higher spatial resolution, do not  
11 allow specific estimation of crop yields, as the information from crops, fallow  
12 vegetation and trees are combined together into a single observation. However, by  
13 comparing a given period of the current year with those from previous years when  
14 conditions were known, or with the mean of all previous years, a reasonably reliable  
15 estimate of the productivity of the growing season and ultimate yield can be  
16 developed. Spectral vegetation indices are usually composed of red and near-  
17 infrared radiances or reflectances (Tucker, 1979), and are one of the most widely  
18 used remote sensing measurements (Cracknell, 2001). They are highly correlated  
19 with the photosynthetically active biomass, chlorophyll abundance, and energy  
20 absorption by plants (reviewed in (Myneni et al., 1995)).

21 Data from the Advanced Very High Resolution Radiometer (AVHRR) sensor is  
22 available at coarse resolution (8 km) resolution (Figure 4) every 15 days since 1981  
23 July, the longest record available to analysts interested in agricultural dynamics

1 (Tucker et al., 2005). By comparing the data from the current period to the average  
2 of the same period from the previous 25 years, a robust estimate of how the current  
3 season is doing compared to previous can be made. Figure 4 shows green areas  
4 where the June-August growing season in West Africa was above average and  
5 brown areas with below-average vegetation density. These anomalies have been  
6 shown to be related to variations in overall cereal production (Funk and Budde,  
7 2008).

8       The Moderate Resolution Imaging Spectroradiometer (MODIS) and the  
9 European SPOT-4 Vegetation sensors are the two datasets most frequently used by  
10 FEWS NET for monitoring at higher resolutions than is possible with the AVHRR  
11 sensor (Huete et al., 2002). Moderate spatial resolution (250m to 1 km) and weekly  
12 (8, 10, and 16 day) time intervals from the MODIS (Figure 5) and SPOT Vegetation  
13 (VGT) sensors have demonstrated their utility in characterizing the structure,  
14 metabolism, and functioning of ecosystems (Huete et al., 2006, Maisongrande et al.,  
15 2004). FEWS NET uses primarily vegetation data from the AVHRR, MODIS and SPOT  
16 Vegetation data because they are global and have daily or twice-a-day coverage  
17 (Brown and De Beurs, 2008). Thus, using satellite remote sensing FEWS NET can  
18 determine if the cropping season in an area will be better or worse than last year or  
19 from the average (Hutchinson, 1998).

20       Table 2 provides a list the extensive number and type of data used by FEWS  
21 NET to summarize the current climatic situation. The data include precipitation  
22 gauges and gridded data from merged satellite models, vegetation data from a  
23 variety of sensors, gridded cloudiness products, global climate indicators,

precipitation forecasts, modeled soil moisture, gridded fire products, snow extent products, hydrological models for flood forecasting, and seasonal forecasts. These data products were either developed directly by FEWS NET partners for FEWS NET or were adapted to their needs.

The table illustrates how gridded rainfall images produced every ten days have been used to drive a large number of models from a variety of disciplines, including agronomic models specifying the moisture requirements of a particular crop given an underlying soil type (Water Requirement Satisfaction Index or WRSI (Verdin and Klaver, 2002)) and the flooding potential given the soil water holding capacity and the amount of water that has fallen on a given catchment basin (Basin Excess Rainfall Model or BERM) (Senay et al., 2007), among many others. Models allow social scientists to ask questions regarding the direct effect of a particular rainfall deficit on the crop production instead of having to infer from rainfall or vegetation imagery the resulting impact.

Despite the rapid improvement of rainfall data's accuracy and resolution, vegetation Index data derived from satellites remains an important source of information for the FEWS NET program (Brown et al., 2006). Although rainfall has been used extensively to drive many other models, it can be less reliable in regions with few gauge measurements with which to calibrate the data. Rainfall data can be prone to errors in approximating the degree of cloudiness, the amount of rain that has fallen from these clouds or the intensity of the rainfall, inadequate capturing of orographic rainfall, and other effects which result in significant random error and non-negligible bias (Waymire, 1985, Xie and Arkin, 1997). Vegetation remote

1 sensing measures directly the stable photosynthetic activity resulting from rainfall  
2 and is thus can be more precise (Tucker et al., 1991, Tucker et al., 2005). Because  
3 they measure very different things, both variables continue to be of value to hazard  
4 monitoring (Brown et al., 2007).

### 5 **3. Example from Afghanistan of How Remote Sensing provides** 6 **Early Warning of Food Insecurity**

7       Hunger remains a significant problem in Afghanistan. Nearly 40% of the  
8 rural population cannot count on having sufficient food to satisfy their most basic  
9 needs. The Afghan diet, consisting mostly of grains, has little variety, creating a  
10 serious problem of malnutrition. The remote sensing tools used by FEWS NET in its  
11 ongoing responsibility to monitor and report on the food security situation in the  
12 country are unique for Afghanistan, since the agrometeorology in the region is  
13 completely different than in Africa or Central America, the other regions where it  
14 works. New operational monitoring products developed include data on  
15 temperature extremes, wind, accumulated rainfall in both liquid and snow form,  
16 crop models for pastoral, rain fed and irrigated crops, and the formation and melting  
17 of the annual snow pack, which provides the majority of the irrigation water for  
18 communities in the north.

19       Food security terminology emerged in Afghanistan in the late 1990s and is  
20 still evolving. A comprehensive national framework for understanding food security  
21 that includes multiple indicators does not exist. Nonetheless, two indicators have

been used for assessing food insecurity in Afghanistan: 1) food consumption, and 2) dietary diversity. Food consumption looks at the quantity of food eaten over a seven day period, while dietary diversity measures the quality of food eaten over a seven day period. Generally, people tend to know what they eat instead how much they eat. Therefore, FEWS NET Afghanistan chose to use the dietary diversity indicator in its analysis. The most recent dietary diversity data from the vulnerability assessment conducted in 2005 showed that 24% of the Afghan population has very poor diversity in their food consumption, including 15% of urban, 25.8% of rural, and 38.3% of nomad populations (Figure 6).

Stunting, which primarily results from lack of access to food over a long period of time, is at a very high level in Afghanistan: 2004 nutrition data indicate more than half (54 percent) of preschool age Afghan children are stunted and 36 percent underweight. Thus FEWS NET refers to food insecurity in Afghanistan as chronic, not transitory (Smith and Haddad, 2000). Despite, or perhaps because of, the long term nature of the problem in Afghanistan, understanding and rapidly responding to variations in food production due to the weather is critical to alleviating crises. Addressing the long term vulnerability of the population will require development and stability which are beyond the scope and mandate of FEWS NET. Remote sensing data provides information which otherwise would be difficult to get in a timely manner due to the ongoing hostilities in the country and fragmented nature of governance.

Unlike regions in the tropics, Afghanistan has its wet season in the winter. Snow accumulates to become a primary source of water for agriculture during the



1 summer (Figure 7). To measure how much water will be available for growing  
2 crops with irrigation water, FEWS NET monitors the rate of snow accumulation and  
3 during the spring, rate of melting. A new index from MODIS is used to estimate  
4 snow cover extent (Figure 8) is coupled with the Air Force Snow Water model that  
5 enables an estimation of the amount of water that is present in the snow pack. The  
6 (daily) snow water equivalent maps show the spatial distribution of the modeled  
7 water content of the snowpack and the spatial distribution of snow cover extent,  
8 and provide an indication of relative snow depth and water available for irrigation  
9 when the snow melts. Five years means were calculated for each day of the year  
10 based on data from the years 2003 to 2007 (USGS, 2008).

11         Daily snow maps are used to calculate snow cover depletion curves, which  
12 relate the percent of a basin or zone that is covered by snow to elapsed time during  
13 the snow melt season. The depletion curves help provide an indication of the  
14 temporal and spatial extent of seasonal snow pack available for irrigation. A steep  
15 decrease in snow-covered area can be indicative of either shallow snow pack or high  
16 melt rates. On the other hand, a slow decrease results from either a deep snow cover  
17 or slow melt rates, most likely due to low temperatures. Plotting snow cover versus  
18 degree days can help reduce this ambiguity, however these depletion curves  
19 measure the maximum extent of snow cover as a function of time without regard to  
20 air temperature (Figure 9). Also note that in these curves, current information is  
21 combined with forecasts for the next 6 days.

22         According to climatic records, precipitation in Afghanistan has declined for  
23 forty years. Annual precipitation averaged about 14 inches (350 mm) in Kabul in

1 the 1960s. In the 1990s the average annual precipitation in Kabul was about 10  
2 inches (250 mm). The resulting droughts and years of insufficient rainfall and snow  
3 runoff in Afghanistan have become more frequent. Small declines in precipitation  
4 and irrigation water reduce coping capacity for poor farmers who are already  
5 vulnerable due to social, political and economic upheaval due to conflict. In a  
6 country in which 85 percent of the people depend upon agriculture for at least part  
7 of their livelihood, knowing the availability of water is crucial to estimating how  
8 much assistance may be needed.

9 FEWS NET combines analysis of potential agricultural production variations  
10 derived from remote sensing with timing, food prices and demand in order to create  
11 a comprehensive analysis of the vulnerability to food insecurity and the need for  
12 response by decision makers. Food access in Afghanistan is more constrained than  
13 normal in 2008 for households that rely on the market due to the prevailing above  
14 average food prices. Wheat flour retail prices continue to rise, particularly in  
15 southern markets where Pakistan is the primary source of flour supplies because  
16 Pakistan has imposed restrictions on flour exportation. Additional pressure on flour  
17 prices is due to the increase in the international price of wheat during 2007 and  
18 2008, which is the result of a number of factors, including agroclimatic conditions  
19 (drought) in key producing areas of Australia and Argentina, substitution in  
20 production from wheat to maize for biofuel processing in the United States, and  
21 increased grain and beef consumption in populous countries such as China and  
22 India as a result of high economic growth and increasing incomes per capita.

1           Snowfall during the 2007/08 wet season was below normal, which  
2 significantly reduced the availability of irrigation water for pre-winter cultivation in  
3 September and October of 2008. The deficits will also cause irrigation water  
4 scarcities for spring planting in March and April, reducing prospects for the main  
5 2008 harvest that begins in May. Rainfall from February through April is critical for  
6 rainfed crops, which are primarily grown in the north.

7           A comparative analysis of 2000-2008 Normalized Difference Vegetation  
8 Index imagery indicates that the 2008 drought has been the most severe during  
9 2008. Coupled with chronic food insecurity, high food prices and escalating civil  
10 insecurity in southern Afghanistan, this drought has led to widespread food  
11 insecurity affecting 35 percent of the Afghan population. In July, the Afghan  
12 government and the United Nations jointly appealed for \$404.3 million in  
13 emergency aid. This appeal level was developed through an analysis conducted at  
14 FEWS NET which included this NDVI analysis. Thus remote sensing will continue to  
15 be at the forefront of analysis and monitoring of food security situation in  
16 Afghanistan.

#### 17   **4. Hazard Monitoring and Food Security Outcomes**

18  
19   Although remote sensing data is an extremely important resource for FEWS NET, it  
20 is a challenge to keep the focus on the food security outcome of the hazard that the  
21 data identifies, not on the hazard itself. FEWS NET uses a food economy approach  
22 and livelihoods analysis that identifies specific causes of a food security crisis for a  
23 particular group of people. Because evidence from remote sensing data is so

1 compelling and has been used in some of the regions where FEWS NET works for  
2 several decades, it is much easier to focus on the easy to understand hazard and not  
3 on the complex and multi-dimensional consequences of the hazard. Thus the  
4 challenge for FEWS NET is to maintain its focus on the diverse and complex local  
5 situation while at the same time providing compelling evidence for action for  
6 decision makers.

7 Another challenge for FEWS NET is the difficulty of finding the resources,  
8 time and managerial focus it takes to maintain databases of all the geographic  
9 information required to conduct food security analysis. Everything from properly  
10 aligned GIS layers of administrative regions and livelihood zones to databases of  
11 historical livestock prices and local rain gauge datasets require management and  
12 maintenance. Although USAID does invest in some of this work, much of it is done  
13 informally and without explicit funding in the current task structure. Thus FEWS  
14 NET needs to reduce the number of steps it takes from data creation to data storage  
15 in order to be able to do more with fewer resources. Long term funding remains the  
16 primary obstacle, however, to ensure that archiving of currently existing datasets is  
17 done in a way to facilitate their integration into modern georeferenced web servers  
18 that can distribute the data to all who need it. Expansion of data sources and  
19 continual investment in ensuring that livelihood baselines, for example, are current  
20 is also required. Adequate funding of the FEWS NET activity would ensure that  
21 these tasks are not marginalized in the face of current demands on resources.

22 Remote sensing continues to be an important part of the work that FEWS  
23 NET does. It provides information that becomes the basis for coalition building

1 during negotiations for humanitarian assistance. By finding groups with common  
2 interests, and then forming alliances to strengthen their combined ability to push  
3 for the desired outcomes, FEWS NET ensures a proper response to food security  
4 crises when they occur. FEWS NET's information gathering must provide the data  
5 needed to provide early warning of an impending crisis, and to advise local, national  
6 and international governments and organizations on programs to reduce the  
7 likelihood that a crisis may occur at all. By arming key participants in negotiations  
8 with clear, actionable evidence of need based both on sound analyses of problems of  
9 access to food as well as food availability, improved response can be ensured.

10

11

## 1    **Captions**

2    **Fig. 1.** FEWS NET country locations and levels of services, as of 2007.

3    **Fig. 2.** Six examples of FEWS NET reports available monthly or quarterly for  
4    decision makers at the local, national, regional and international levels.

5    **Fig. 3.** The seven most frequently cited drivers in 49 studies of household-level food  
6    insecurity in southern Africa, derived from 555 citations of 33 possible drivers. The  
7    drivers shaded in grey were noted as being chronic, while those in white indicate  
8    drivers that were experienced as 'shocks'. The shaded arrows indicate drivers that  
9    acted primarily via reductions in food production, while the white arrows indicate  
10   those which acted by restricting access to food. Derived from (Cooper et al., 2004,  
11   Gregory et al., 2005).

12   **Fig 4.** AVHRR data for Africa, anomaly for September 2008.

13   **Fig. 5.** MODIS vegetation and anomaly data

14   **Fig. 6.** Estimate percent of the population who are food insecure in Afghanistan  
15   from the National Risk and Vulnerability Assessment 2005, conducted by  
16   Government and Stakeholders from July-September 2005.

17   **Fig 7.** Seasonal calendar and critical events timeline

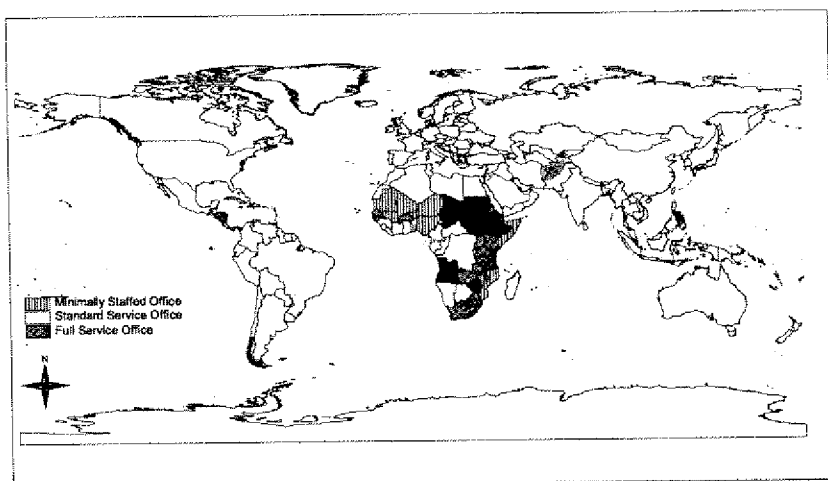
18   **Fig. 8.** MODIS snow cover extent difference from previous period for March 11-21,  
19   2008, Afghanistan based on MODIS 8-day normalized difference snow index.

20   **Fig. 9.** Snow water accumulation/depletion curves for an individual basin.

21   **Table 1.** Use of remote sensing-based data by people in different communities, at  
22   different scales (from R. Choularton, FEWS NET web site).

1 **Table 2.** List of all remote sensing and socio-economic datasets used by FEWS NET

1

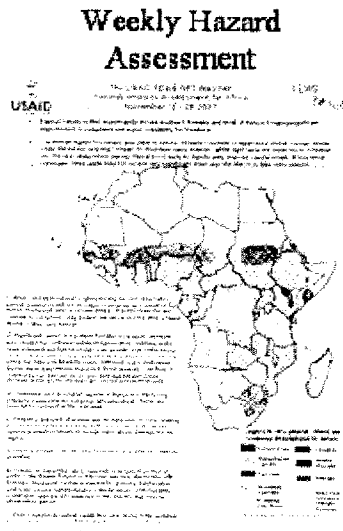


2

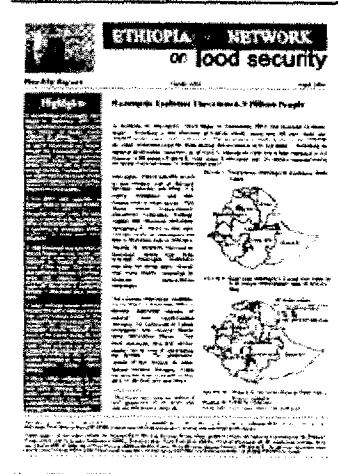
3 **Figure 1.**



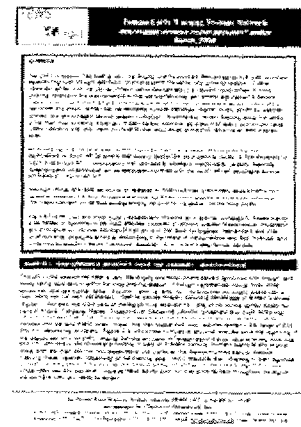
1



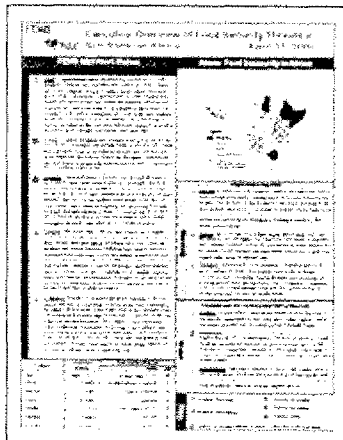
## Country Reports



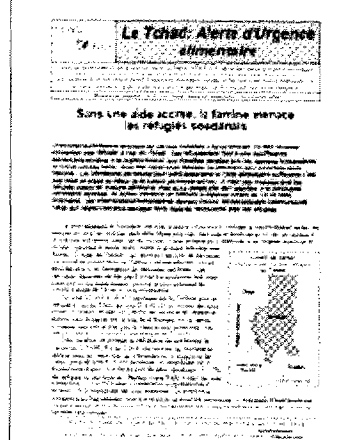
## Regional Reports



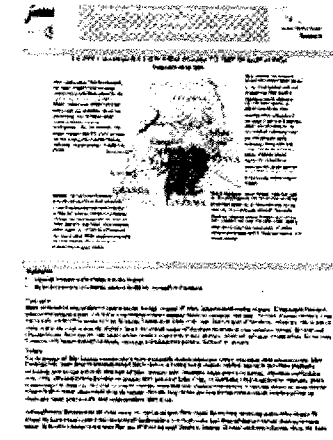
## Executive Overview



## Alert Statements

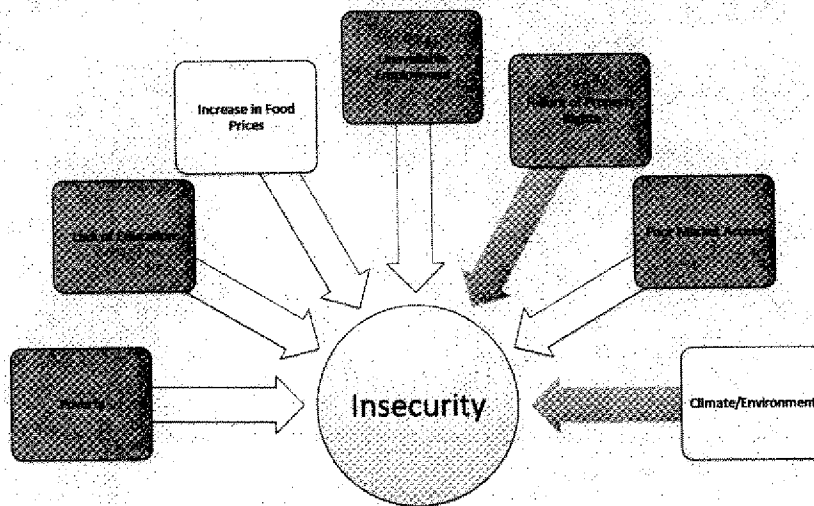


## Market/Trade Information



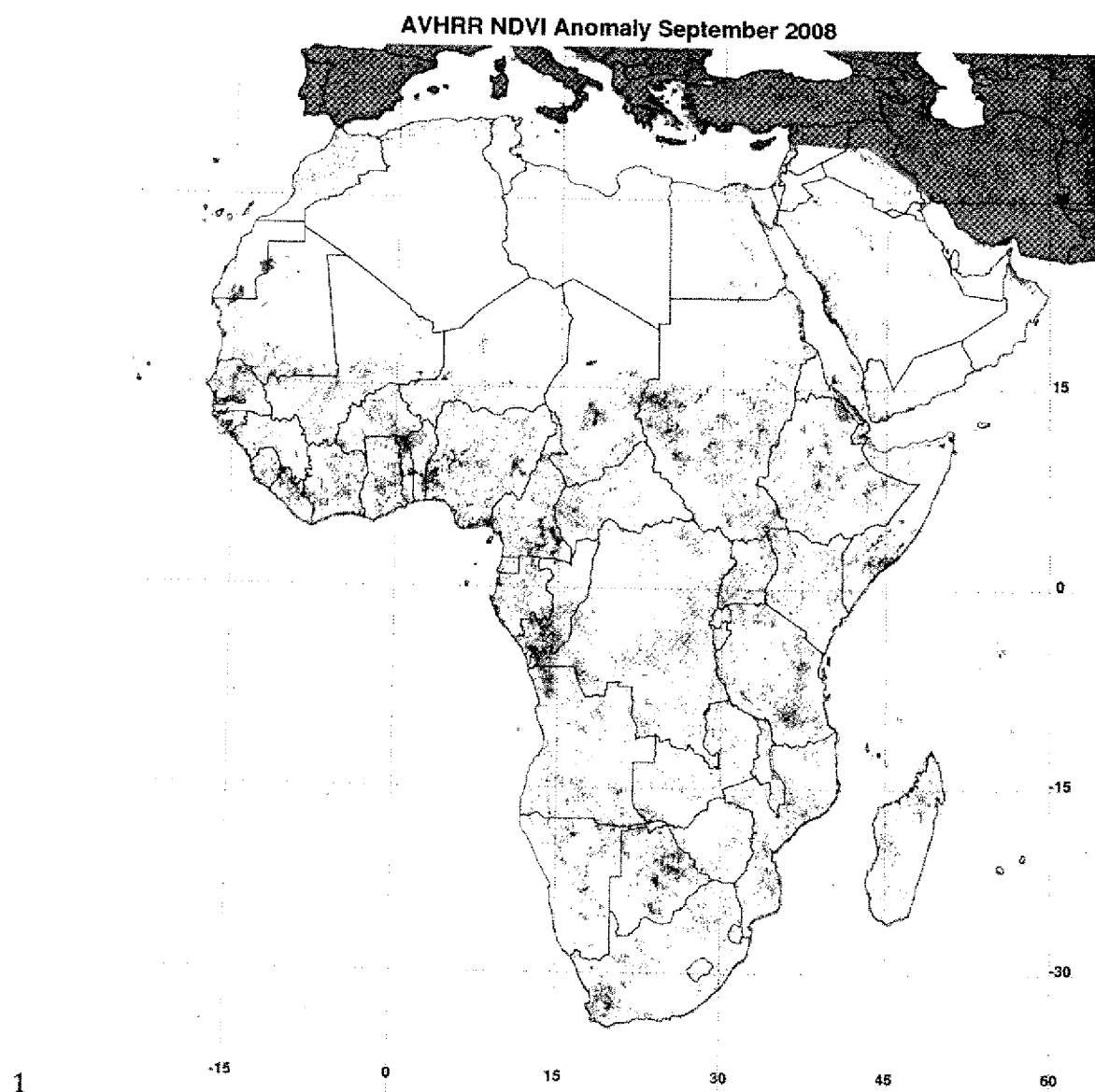
2

3 Figure 2.

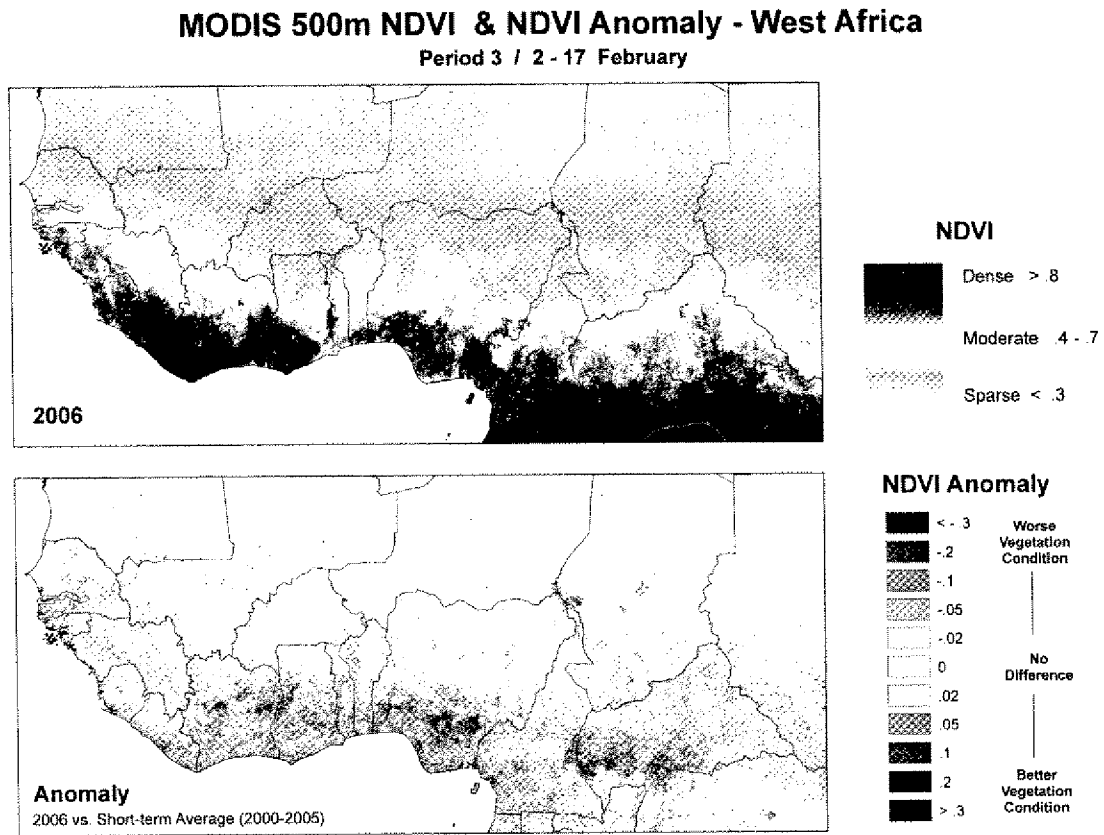


1.

2 Figure 3.



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2

Data based on temporally smoothed times series NDVI imagery to reduce the effects of cloud contamination and other atmospheric perturbations. See explanation for more details.

3

Figure 5.

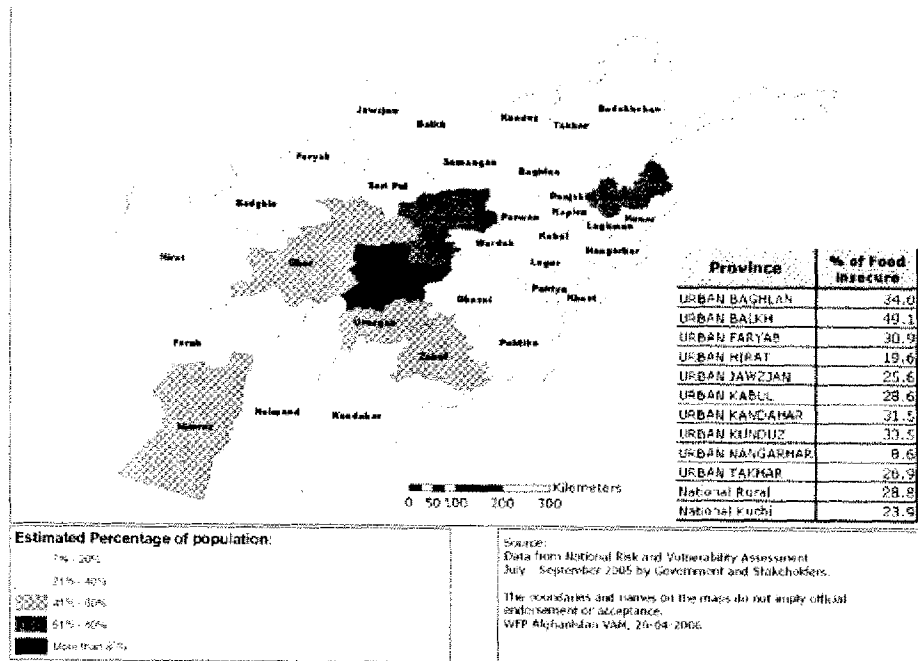


Figure 6.

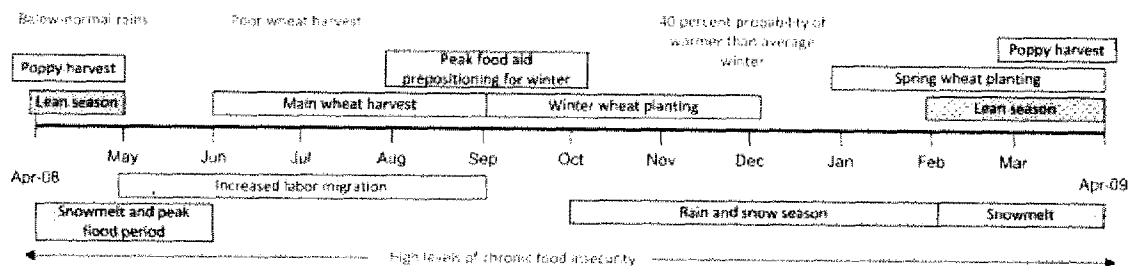
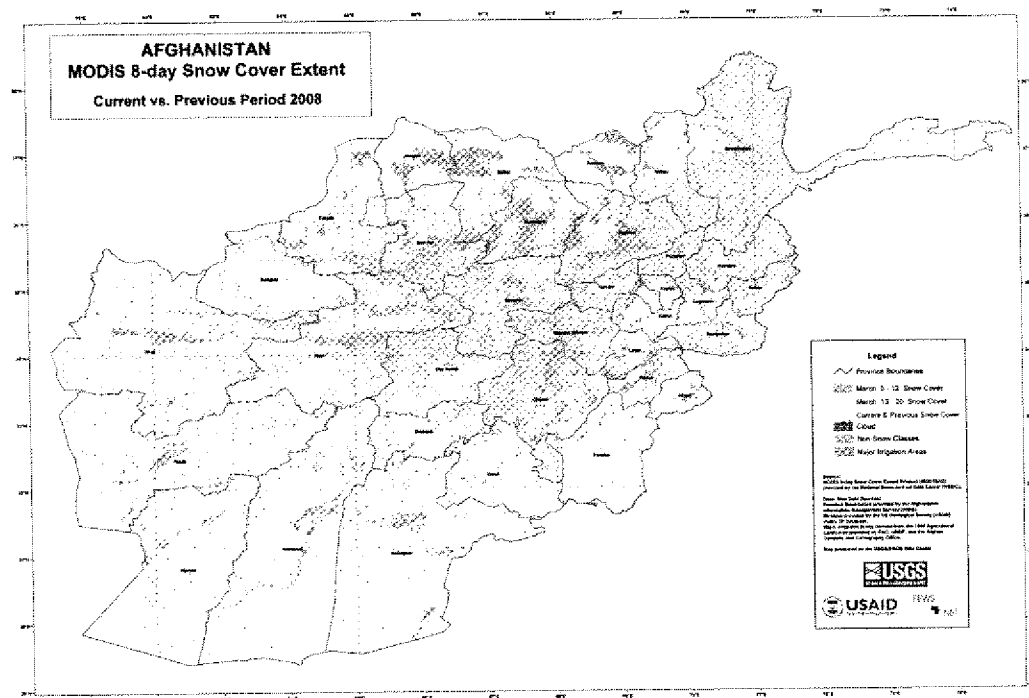


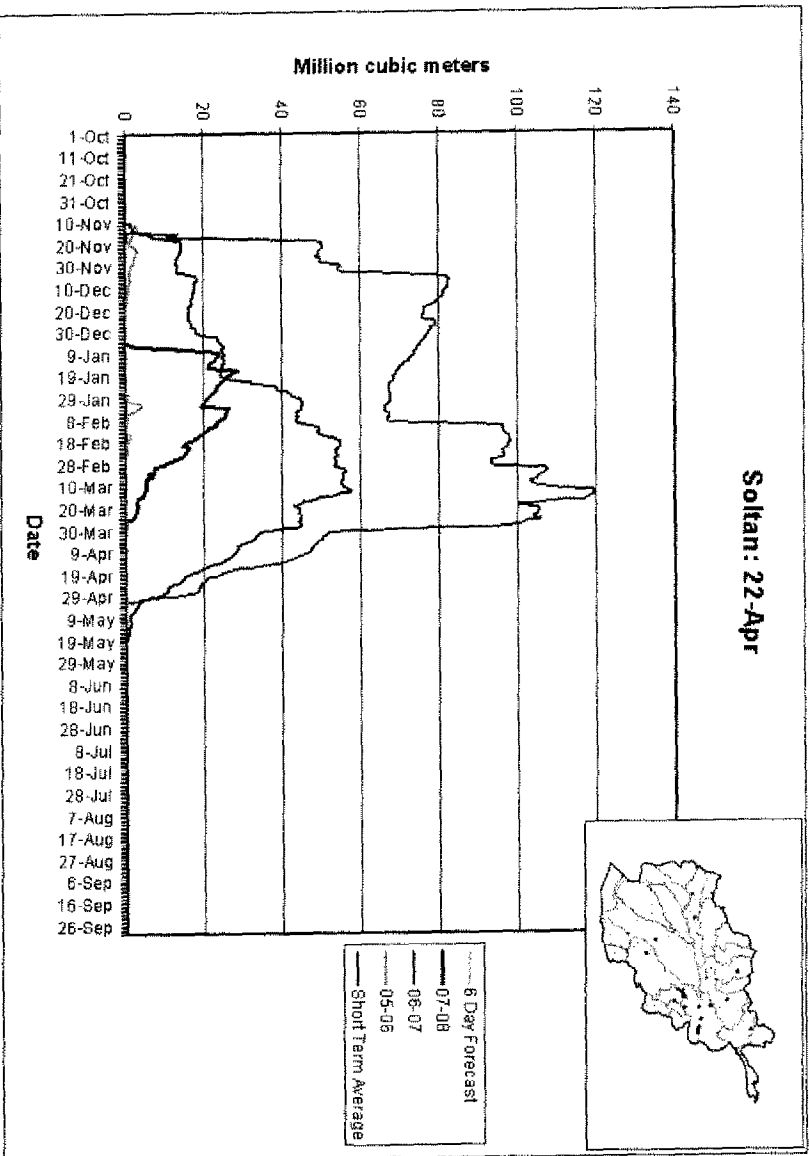
Figure 7

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2



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4 Figure 8.



1  
2  
3 Figure 9.

1

2 Table 1.

|   | <b>Local</b>                         | <b>National</b>                            | <b>Regional</b>                 | <b>International</b>                          |
|---|--------------------------------------|--|---------------------------------|---|
| <b>Community</b>                        | Individuals with access              |  |                                 |   |
| <b>Civil Society</b>                    | Local NGOs                           | National NGOs                              | Regional NGOs                   | International NGOS (Save the Children, Oxfam) |
| <b>Government or intra-governmental</b> | Municipal or departmental government | Ministry of Agriculture, Health Parliament | ECOWAS<br>SADC<br>African Union | United Nations General Assembly               |
| <b>Private Sector</b>                   | Local shop owner or trader           | National Companies                         | Regional Companies<br>CILSS     | Transnational Corporations<br>FAO<br>WFP      |
| <b>International organizations</b>      |                                      | National Government<br>Private sector      | African Development Bank        | USAID<br>DFID<br>EU                           |
| <b>Donors</b>                           |                                      |  |                                 |   |

3

4



**Table 2.** Current FEWS NET data products and descriptions.

| Category               | Type                           | Product  | Description  | Spatial Extent                      | Spatial Resolution | Time Step                     | Source (see acronym list for definitions) |
|------------------------|--------------------------------|--|--|-------------------------------------|--------------------|-------------------------------|---|
| Biophysical Monitoring | Precipitation                  | RFE - Rainfall Estimate                            | multi-sensor and gauge merged model  | Africa, SE Asia, SW Asia            | 0.1 deg            | daily                         | NOAA CPC                                  |
|                        |                                | Unbiased RFE                                       | RFE with post processing unbiasing procedure that tunes imagery to historical rainfall             | Africa                              | 0.1 deg            | Daily                         | USGS                                      |
|                        |                                | TRMM - Tropical Rainfall Monitoring Mission 3b42RT | multi-sensor and gauge merged model  | global                              | 0.25 deg           | daily                         | NASA GSFC                                 |
|                        |                                | GTS Station Data - Global Telecommunication System | station data, daily  | global                              | point              | daily                         | United Nations (WMO)                      |
|                        |                                | CMORPH - NOAA CPC Morphing Technique               | multi-sensor and gauge merged model (NO gauge data in CMORPH)                                      | global                              | 0.1, 0.25 deg      | daily                         | NOAA CPC                                  |
|                        |                                | Projected Rainfall                                 | 1-3 month predicted rainfall data  | Africa                              | 0.1 deg            | Daily                         | USGS, UCSB                                |
|                        | Derived Precipitation Products | SPI - Standardized Precipitation Index             | 18-yr mean standardized anomaly (30-yr mean for Africa SPI, not familiar with the SW Asia product) | Africa, SW Asia                     | 0.1 deg            | 10 day, 1, 2, 3, 6 and 12 mon | UCSB, USGS                                |
|                        |                                | SOS - Start of Season                              | determines beginning of growing season   | Regional (Africa, C.America, Haiti) | 0.1 deg            | daily, seasonal               | USGS                                      |
|                        |                                | ITCZ - Inter-Tropical Convergence Zone             | estimates onset of rains approx. week before   | Regional (Africa)                   | vector coverage    | daily, seasonal               | NOAA CPC                                  |
|                        |                                | WRSI - water requirement satisfaction index        | estimates crop yields by crop type   | Africa, SW Asia, C.America, Haiti   | 0.1 deg            | daily, seasonal               | USGS                                      |
|                        |                                | Rangeland WRSI                                     | estimates rangeland grass condition  | Africa,                             | 0.1 deg            | 10-day, seasonal              | USGS                                      |

**Table 2.** Current FEWS NET data products and descriptions.

| Category               | Type                      | Product   | Description   | Spatial Extent                | Spatial Resolution | Time Step                | Source (see acronym list for definitions) |
|------------------------|---------------------------|---|---|-------------------------------|--------------------|--------------------------|---|
| Biophysical Monitoring | Clouds                    | OLR - Outgoing long wave radiation                              | precipitation proxy   | global                        | 8km                | hourly                   | NOAA CIRES Climate Diagnostics Center     |
|                        |                           | IR - Infrared Temperature                                       | precipitation proxy   | global                        | 25 km              | hourly                   | NASA GSFC Global Change Master Directory  |
|                        |                           | Water Vapor - MODIS   | precipitation proxy   | global                        | 1 km               | daily                    | NASA GSFC                                 |
|                        |                           |   |   |                               |                    |                          |   |
|                        | Global Climate Indicators | MJO IR - Madden Julian Oscillation/ 200 h/PA velocity potential | upper level convergence, precip predictor                           | global                        | 25 km              | hourly                   | NOAA CPC                                  |
|                        |                           | GFS Vorticity   | upper level convergence, precip predictor                           | global                        | 0.5 and 1.0 deg    | 4x daily                 | NOAA                                      |
|                        |                           | ENSO phase - Sea Surface Temp Anomalies                         | related to seasonal precipitation in some regions                   | global                        | 25 km              | daily                    | IRI and NOAA CPC                          |
|                        | Precipitation Forecast    | GFS model - Global Forecast System                              | precipitation forecast – 24-168 hour                                | global                        | 0.5 and 1.0 deg    | 4x daily                 | NOAA                                      |
|                        |                           | NCEP/Eta model  | precipitation forecast – 24- 72 hour                                | regional models               | 22 km              | 3-hourly                 | NOAA CPC                                  |
|                        | Vegetation                | AVHRR GIMMS NDVI (normalized difference vegetation index)       | vegetation density and health                                       | global                        | 8km                | 10 and 15 day composites | NASA GSFC                                 |
|                        |                           | AVHRR NOAA Vegetation Health                                    | vegetation plus temperature   | global                        | 16 km              | Weekly (7 day)           | NOAA                                      |
|                        |                           | SPOT Vegetation NDVI  | vegetation density and health                                       | global                        | 1km                | 10 day composites        | VITO, FAS-USDA, NASA GSFC                 |
|                        |                           | MODIS NDVI Projections based on CMG product                     | Projections of vegetation density 1, 2 and 3 months into the future | Africa                        | 5000 m             | Monthly                  | NASA, UCSB, USGS                          |
|                        |                           | MODIS NDVI - MOD13  | vegetation density and health                                       | global - limited availability | 250 m              | 16 day composites        | NASA GSFC                                 |

**Table 2.** Current FEWS NET data products and descriptions.

| Category | Type          | Product                                 | Description  | Spatial Extent  | Spatial Resolution | Time Step       | Source (see acronym list for definitions) |
|----------|---------------|---|--|-----------------|--------------------|-----------------|---|
|          | Soil Moisture | MODIS NDVI – MOD09 one day latency prod | Vegetation data created from MOD09 data with 9 hour latency          | Global          | 250m, 500m         | 8 day and daily | NASA GSFC                                 |
|          |               | SSM/I Soil Moisture                     | soil moisture, vegetation proxy                                      | global          | 30km               | weekly, monthly | NOAA                                      |
|          |               | CPC Leaky Bucket model                  | soil moisture, vegetation proxy                                      | global          | 25km               | monthly         | NOAA CPC                                  |
|          |               | MI - Moisture Index                     | estimates available water for crops/vegetation (supply/demand ratio) | Africa, SW Asia | 0.1 deg            | daily, 10-day   | USGS                                      |
|          |               | SWI – Soil Water Index                  | Estimates amount of water available for crops/vegetation             | Global, Africa  | deg, 25 km         | 10-day, monthly | USGS                                      |
|          |               |   |  |                 |                    |                 |   |

**Table 2.** Current FEWS NET data products and descriptions.

| Category                  | Type                    | Product  | Description   | Spatial Extent                | Spatial Resolution | Time Step             | Source (see acronym list for definitions) |
|---------------------------|-------------------------|--|---|-------------------------------|--------------------|-----------------------|---|
| Biophysical Monitoring    | Fires                   | MODIS Rapid Response                             | fire locations mapped onto true color MODIS imagery     | global - limited availability | 250 m              | daily                 | NASA GSFC                                 |
|                           | Snow                    | Snow station data                                | precipitation, snow fall and temperatures               | Asia                          | point              | daily                 | AFWA                                      |
|                           |                         | Snow depth grid                                  | Modeled data using SSM/I surface temps + climatology    | Asia                          | 48km               | daily                 | AFWA                                      |
|                           |                         | Snow cover                                       | AMSU Microwave from NOAA-satellites 15 and 16           | Asia                          | 24km               | daily                 | NOAA NESDIS                               |
|                           |                         | Snow Water Equivalent                            | Spatial implementation of the Utah Energy Balance model | Afghanistan                   | 0.1 deg            | daily                 | USGS                                      |
|                           | Hydrology               | BERM - Basin excess rainfall model - flooding    | basin flood potential driven by NOAA RFE Precipitation  | Africa                        | by basin           | daily                 | USGS                                      |
|                           |                         | Reservoir levels                                 | global reservoir and lake elevation from radar          | Globe, selected               | by water body      | monthly               | FAS-USDA, NASA                            |
|                           |                         | Cyclone Monitoring                               | image of cyclone track from Navy                        | E.Africa                      | -                  | daily                 | JTWC-NOAA CPC                             |
|                           | Seasonal Forecasts      | IRI SSTA + COLA AGCM temp and precip predictions | guidance for upcoming agricultural season               | global                        | 1-5 degree         | 3-month               | NOAA-CPC, Columbia IRI                    |
| Socio-Economic Monitoring | Agricultural Production | production figures for various commodities       | production statistics from selected countries           | Africa                        | -                  | Seasonal              | FEWS/ UN (FAO)                            |
|                           | Market Prices           | market prices for various commodities            | commodity prices from markets in selected countries     | Africa                        | -                  | Monthly and/or weekly | FEWS                                      |

**Table 2.** Current FEWS NET data products and descriptions.

| Category                  | Type                 | Product  | Description  | Spatial Extent | Spatial Resolution | Time Step                | Source (see acronym list for definitions)           |
|---------------------------|----------------------|--|--|----------------|--------------------|--------------------------|---|
| Socio-Economic Monitoring | Food Economy Zones   | Livelihood Zone Maps                                 | map shows division of country into uniform zones                     | Global         | -                  | static - periodic update | FEWS  |
|                           |                      | Livelihood Zone Profiles                             | describes cash income and food production sources                    | Global         | -                  | static - periodic update | FEWS  |
|                           |                      | Scenario modeling baselines                          | describes impact of different shocks                                 | Global         | -                  | static - periodic update | FEWS  |
|                           | Employment           | Monitoring of labor markets                          | Wage-earning is a critical piece of the local economy in many places | Africa         | -                  | Ongoing                  | NGOs, local government through FEWS Representatives |
|                           | Population           | Monitoring of migrant vs permanent population levels | Large movements of populations can signal a food crises              | Africa         | -                  | Ongoing                  | NGOs, local government through FEWS Representatives |
|                           | School Attendance    | Local Representatives monitor attendance rates       | To determine if food crisis is occurring                             | Africa         | -                  | Ongoing                  | NGOs, local government through FEWS Representatives |
|                           | Infra-structure Maps | Roads, administrative maps, infrastructure maps      | enables rapid response in event of emergency                         | Global         | -                  | static - periodic update | UN WFP/FEWS   |

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